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THE AUDIBILITY OF THE AURORA

By C. A. CHANT

FOR some years I have been collecting evidence regarding the audibility of the aurora, and notes embodying information gained have been printed in this JOURNAL from time to time. On March 24, 1922, there appeared in the *Toronto Globe* an article on the editorial page, which discussed an address before the Royal Geographical Society by Mr. G. M. Gathorne-Hardy, who claimed that he had heard a characteristic sound from the aurora while he was in Labrador in the autumn of 1920. The speaker, it was stated, was a man of standing; he had been a distinguished student at Oxford and was a wide traveller. He was quoted as saying:

> Two points occur to me as worthy of mention in this connection. The first is that I have occasionally seen what appears to be the aurora by day, in the form of faint clouds having the characteristic appearance of the bands and streamers. The second point I raise with some hesitation, as I believe the balance of scientific opinion is against its possibility. That is, that, judging merely by the evidence of my senses, I should say that I had sometimes heard the aurora, when in rapid movement, making a faint, crisp, rustling noise. If this is a hallucination, it is a very strange one.

The article also gives the evidence of Captain H. P. Dawson, who was in charge of the British Polar station at Fort Rae in 1882-83 and who wrote:

> The Indians and the voyageurs of the Hudson's Bay Company, who often pass their nights in the open, say that it (the sound) is not uncommon.

On one occasion Dawson himself heard it and he says:

> The sound was like the swishing of a ship or the noise produced by a sharp squall of wind in the upper rigging of a ship.

That the subject aroused great popular interest was shown by the number of letters to the editor which it called forth. When these had ceased coming in, I made a request, through the same paper, that any others who had made observations on the phenomenon and who did not care to write to the press would send me statements regarding them. This brought to me some very interesting letters.

When in Ottawa some months later, I learned that several men in the Department of the Interior had interesting experiences to relate, and through the assistance of Mr. W. W. Cory, Deputy Minister, and Mr. R. Meldrum Stewart, Acting Director of the Dominion Observatory, I have been supplied with some of these.

In what follows I give extracts from the various communications I have received. In most cases only the bare statement of the observations is given; attempts at theorizing or aspersions on the scientists for being so slow to believe are omitted.

Dr. O. C. J. Withrow, Toronto (*Globe*, April 7):

> For many years I lived in Fort William, Ont., and there one sees the aurora in all its brilliancy and grandeur. In the silent midnight hours I have been frequently called from my bed in the practice of my profession, and have many times seen the heavens swept by the majesty of this manifestation of nature's handiwork. Many a time I have heard a swishing sound, which I have always felt came from the aurora.

Miss Rose Duncan, Forest, Ont. (*Globe*, April 7):

> I lived on St. Joseph's Island a great many years, in a very quiet place, where I could account for every sound, especially on a winter's night, and have on several occasions heard sounds I could attribute to nothing else but the northern lights which were very bright. Sometimes the sounds would be quite plain. I do not recall hearing sounds unless the lights were plain.

Mary D. Kennedy, Toronto (*Globe*, April 8):

> I was brought up in the country, in Nova Scotia, and have known all my life that sometimes during certain displays a soft, slithering whisper can be heard. My father used to tell us to "listen and you will hear them change". At such times they seem very near, and move quickly.

F. G. HORNER, Bracebridge, Ont. (*Globe*, April 13):

Having spent several years in the Yukon, three winters being dog-team work that kept me in the wilds, where a tent was our chief habitation, I have had a very good opportunity to observe the aurora in all its grandeur near the Arctic circle. The sounds were very plainly heard in the very cold, dry atmosphere when the aurora was most active and showed the colours of the rainbow.

A. J. WOODWARD, Mimico, Ont. (based on many years of daily meteorological observations (*Globe*, April 22):

There is a distinctly audible noise from the aurora, but only from general displays that produce running waves from horizon to zenith in about one second. If these waves are wide, and consequently nearer, a rustling sound is produced, and the narrower the wave, the sharper the noise, almost to a crackling sound.

MRS. H. F. NASH, Toronto (*Globe*, April 25):

We were staying at the Kootenay Hotel, on the Arrow Lakes, B.C. A party of us took a trip to the Minnie Mack mine and the summit of Silver Mountain, 11,000 feet above sea level. While there we had a wonderful view of the northern lights. Great long shafts of light spread out in the shape of huge fans, waving from side to side like powerful searchlights. We heard a gentle swish, faint but still audible. We watched them for a long time.

E. A. COLLYER, Toronto (*Globe*, April 4):

Coming up the St. Lawrence in September, 1907, I witnessed a great display. The whole northern sky was aglow with shifting lights—the greatest auroral exhibit in my experience. I heard unquestionably a distinct crackling, rustling sound. The vessel was the S.S. Parisian. There was an entertainment in the saloon below, and the deck was almost deserted. Critics will, of course, say it was sounds from the saloon which I mistook for the aurora. But they will be wrong—it came from the heavens and nowhere else.

MRS. ISABEL DAVIDS, Toronto (*Globe*, April 10):

One very cold night many years ago I was walking along College St., when I was attracted to a magnificent display of northern lights, which took on different shapes, at once resembling a huge fan spreading wide, then part way, then closing, and other designs after the manner of a kaleidoscope. The colours were delicate blue, pink and corn colour. While gazing upward I distinctly heard coming from the sky a sound resembling the rustling of silk.

"OBSERVER", Arnprior, Ont. (*Globe*, March 31):

I know for a fact that a sound sometimes accompanies the northern lights, having heard it on at least two occasions in northern Minnesota about the year 1892. During the fall very brilliant displays were seen, and on at least two occasions a faint but unmistakable crisp, rustling sound was heard by myself and others.

REUBEN BUTCHART, Toronto (*Globe*, April 18). Mr. Butchart's letter deals chiefly with the journey of Sir John Franklin to the Polar Sea in 1819-22, and, though rather long, is very interesting. It is given in full:

Based on the recollection of a vivid boyhood experience and conclusion, I had for years assumed that I had heard the Aurora. But now I am not so sure. Nor is it likely that occasional observers in this latitude have any ground but imagination for their beliefs. The "suggestion" of sound is so obvious. My revised opinion is gained from a re-reading of portions of the old classic on the Arctic, Sir John Franklin's Journey to the Polar Sea in 1819-20-21-22. It is apparent that more than one hundred years ago the question of the Aurora being audible was a live one, since the British Government included it in their list of objectives for Capt. Franklin. I quote from the Everyman edition, introduction:

"That I should take particular notice whether any and what kind of degree of influence the Aurora Borealis might appear to exert on the magnetic needle; and to notice whether that phenomenon were attended with any noise."

There are frequent references, and that on page 241 of the same edition is to the point:

"The night was fine and the Aurora Borealis so vivid that we imagined, more than once, that we heard a rustling noise like that of autumnal leaves stirred by the wind; but after two hours of attentive listening we were not entirely convinced of the fact. The coruscations were not so bright, nor the transitions from one shape and colour to another so rapid, as they sometimes are; otherwise, I have no doubt from the midnight silence which prevailed, that we should have ascertained this yet undecided point."

On page 253 the following good story occurs:

"One of the partners of the North West Company related to me the following singular story: 'He was travelling in a canoe in the English River, and had landed near the Kettle Fall, when the coruscations of the Aurora Borealis were so vivid and low that the Canadians fell on their faces, and began praying and crying, fearing they should be killed; he himself threw away his gun and knife that they might not attract the flashes, for they were within two feet of the earth, flitting along with incredible swiftness and moving parallel to its surface. They continued for upwards of five

minutes, as near as he could judge, and made a loud rustling noise, like the waving of a flag in a strong breeze.'"

The reader is now referred to the same book (quarto edition) found in our Reference Library, where, in the appendix devoted to scientific observation, occurs the following:

From Lieut. Robert Hood: "The delicate electrometer suspended at the height of fifty feet from the ground was never perceptibly affected by the Aurora, nor could we distinguish its rustling noise, to which, however, such strong testimony has been given that no doubt can remain of the fact."

Captain Franklin writes: "I have not heard the noise ascribed to the Aurora, but the uniform testimony of the natives, and of the residents of this country, induces me to believe that it is occasionally audible. The circumstances, however, must be of rare occurrence, as is evidenced by our having witnessed the Aurora upwards of 200 times without being able to attest the fact."

Dr. Richardson states: "I have never heard any sound that could be unequivocally considered as originating in the Aurora, but the uniform testimony of the natives, both Crees, Copper Indians and Esquimaux, and that of older residents of the country, induces me to believe that its motions are sometimes audible. These circumstances are very rare, as will appear when I state that I have now had an opportunity of observing that meteor for upwards of two hundred different nights."

Lieut. E. F. Kane of the U.S. Navy, who headed two "Grinnell" expeditions for the relief of Franklin and who reported his findings in several volumes, with scientific notes on the Aurora to the Smithsonian Institution, says nothing of the emanation of sound from it.

Note that the scientific observers heard it not, but that they accepted the testimony of unscientific men, some of whom were under the influence of fear when they "heard." I give it up.

Miss Marietta L. Dingle, Toronto:

While living in Winnipeg with others of my family, and while enjoying some very brilliant displays of the aurora, more than once I have distinctly heard an accompanying sound like a rustle of silk or tissue paper, which certainly was allied to the aurora very closely, and appeared to follow its waves of light as it travelled across the heavens.

Many times during three winters I spent in Winnipeg, 1891-2, 1892-3, and 1904-5, and occasionally in the autumn I saw wonderfully beautiful displays spread out upon the sky softly, like colour on a map, but having no audible accompaniment. When the sound was noticeable the aurora seemed to travel rapidly, in waves of light. The sound was not at all loud, but was decidedly arresting to music-loving ears, and is difficult to describe as it is so distinctive—neither rustling, nor crackling, nor swishing, but a mingling of all three sounds, faint and distant.

not through the air from the streamers to us, for in that case there would have been a lag of more than the one or two seconds observed. Next, it seems most probable that both the aurora and the sound came from the same source—possibly the electric impulse of Hertzian or other waves, or the incidence of the cloud of electrons, or whatever it is that really causes the aurora. Might not the sound come from the discharge of static electrification—remember the state of the atmosphere—in the immediate neighbourhood of the hearers? Could it be a discharge released in some way by the electric impulse accompanying the flash—a sort of photoelectric effect due not to the visible light but to the impact of an electrical disturbance that set up the aurora itself? The nature of the sound (Franklin's jar) makes this suggestion worth thinking over.

I have "heard the aurora" on other nights much more recently, but never on a scale comparable to the occasion I have referred to. I think, however, it was always on dry, frosty weather. I am sorry that I did not know enough at the time to look for brush discharges—a sort of St. Elmo's Fire—on neighbouring objects, but doubt if it would have been visible in the glare of the unusual illumination. I distinctly remember a light that spread over the snow-covered ground that was noticed and discussed at the time. We put it down to a reflection of the light from the snow surface. What a pity that we did not look to see whether this light accompanied the flash or whether it lagged with the sound.

CHARLES HARVEY, Hamilton, Ont:

I have on several occasions heard quite distinctly a sound (which may be described as a subdued swishing sound) accompanying very brilliant displays of the aurora. The first time I noticed this phenomenon was in January, 1888. The place was three miles east and one mile north of Saskatchewan. I was fourteen years old and was on my way home from a neighbour's place. I was very much impressed and considerably frightened and have never forgotten it. A few times since then I have observed the same phenomenon, always on the prairie where I lived from 1883 to 1898.

In the year 1919 while surveying for the Dominion Government, in company with Mr. G. A. Bennett, another Dominion Land Surveyor, while we were camped about nine miles southeast of Broadview, Sask., we noticed the same phenomenon. The atmospheric and other conditions were almost exactly the same in every instance, and so a description of the one which took place about October 15, 1919, will serve for all; and I might here state that these displays seem to be more or less local, as people living a few miles away, while noticing that there was a brilliant aurora, did not notice the accompanying sound.

The hour was about 9 o'clock p.m., not a cloud in the sky, not a breath of air stirring, and the temperature, I should judge, not lower than zero Fahrenheit. We were called out of our tents by one of our men to see the unusually brilliant display of the aurora. It certainly was a sight well

worth watching, but would require a much more able pen than mine to do it justice. Some distance to the north appeared a long, wavy, brilliantly luminous belt stretching roughly in a horizontal line from east to west seemingly at a height of only a few hundred feet above the ground, and moving southward. This brilliant belt, while seeming to fold and unfold on itself, like a bright ribbon which is continually doubling up and straightening out, seemed to keep about the same distance above the ground in its progress southward.

Behind this oncoming wave of brilliance, streamers of light, more or less intense but never so brilliant as the lowest belt, kept shooting up towards the zenith, and the display seemed to fill the whole northern sky. We watched this display approaching from the north. At first there was no sound, but as it got nearer, we heard a subdued swishing sound, which grew more distinct as it approached, and was loudest when the ribbon or belt of light was right overhead.

The sound was at no time loud but was quite distinct for several minutes and seemed to vary in intensity with the brilliance and the wavy motion of the luminous belt. It passed on to the south, and in a few minutes the whole sky was full of auroral streamers which seemed to culminate at a point in the zenith. A few minutes after the first display had passed over our heads, however, we could not hear the sound. It appeared as if the display was too distant for the sound to reach us, and an hour after our attention was first drawn to it the display had faded to quite an ordinary one.

JOHN R. CRAIG, St. Thomas, Ont.:

About the 15th August, 1882, after a day's journey, I with three cowboys, camped on the prairie some 20 miles east of the N.W.M.P. headquarters at Fort McLeod. We built our camp fire and had supper and soon after retired to rest. The night was calm and bright. Lying awake in the tent, I heard a mild crackling noise which brought me outside quickly, fearing that our fire had not been thoroughly extinguished. The fire was dead, but the heavens to the north were showing a greater display than I had ever seen. The aurora was shooting upwards and receding with almost lightning rapidity and with varying colours. A broad yellowish splash of flame spread across from the west to the east, ascending from the horizon and proceeding with what I can best describe as a swishing noise, while at the same time a crackling noise accompanied the darting and shooting of the aurora.

The whole display seemed near. Its immanency impressed me and together with the very clear audibility inspired something bordering on fear. I have been near to pine forest fires and the flames running through the branches made a crackling noise which impressed me as similar to that accompanying the aurora which I am endeavouring to describe.

I was "brought up" on a farm in Toronto Township and often witnessed and admired the aurora, but there never was anything approaching the display I saw and heard in Alberta on or about the 15th August, 1882. There was no settlement. Lethbridge was not born and Calgary had three log buildings. Our camp was about 3,000 feet above sea-level. There was no one in the vicinity but ourselves, and our horses were picketed at a distance. The sound from the aurora was clear, distinct, impressive and so indelible that the forty years which have elapsed have left the audibility of this grand display fresh and clear. There is no exaggeration but on the other hand my description is weak in comparison with the reality.

O. S. Finnie, Department of the Interior, Ottawa:

My recollection of the auroral displays in the Klondyke is that the "crackling" sound was not present, but I distinctly remember hearing a "swishing" sound when the aurora was at its greatest intensity and waving in the sky like a blanket or a sheet.

Major L. T. Burwash, Ottawa:

During the years I have spent in the Canadian Northland I have, on many occasions, been greatly interested in the aurora borealis and have observed it closely.

There is absolutely no doubt as to its audibility. I have heard it most distinctly and have discussed this phenomenon with many persons at the time of its occurrence when all noted identically similar hissing or crackling sounds. That these were directly caused by the aurora, there can be no doubt as they coincided with it as to time, commencing as the light of the aurora began to intensify, following it in its course across the sky and dying as the light faded.

These sounds are very similar to those known to wireless operators as "static disturbances", which so frequently interfere with the receiving of aerial messages. The effect of these disturbances when intensified or concentrated by the ordinary wireless instruments may be divided into several divisions.

(1) The more or less constant sounds, much like those made by an effervescing fluid.

(2) The sharp staccato sounds which come at more or less regular intervals.

(3) The heavier and duller sound coming at somewhat irregular intervals and resembling the "knock" which is heard in a defective engine.

The sounds accompanying the aurora are identical with the first two of the above divisions, the first not being as intense as I have heard from a wireless instrument, and the second, while distinctly present, being much subdued. The third and heaviest disturbing sound I have not heard from the aurora.

MR. W. W. CORY, Deputy Minister of the Interior, states that his experience in the Yukon and in Manitoba corroborates Major Burwash's comparison of the auroral sounds to the first two kinds of wireless disturbance mentioned above.

C. B. BURNS, Ottawa:

While I was in the Yukon I observed the aurora many times with great interest. We used to have "aurora parties", at which times we would sit up for hours paying great attention to the skies. There certainly was a distinct crackling sound, varying in sharpness apparently according to the state of the atmosphere. On my drive in 1903 with you [Mr. Cory], we heard the same sound, I remember.

IS THERE A SOUND EMITTED?

After reading the foregoing evidence one can hardly withhold belief that a sound is heard during some auroral displays. True, it is rather disturbing to learn that some scientific observers who have listened intently have not been able to perceive any sound; but a considerable number of those who kindly contributed a record of their experiences were capable observers. In some cases their attention was drawn to the aurora by hearing the sound. In more than one instance several persons in a party heard the sound and discussed it at the time. It has been remarked that in the deep stillness of the night, when bright streamers dart rapidly across the sky or brilliant curtains wave above the head, one almost expects to hear a sound; but I cannot think that all the observers have been deceived.

It would appear that a sound is heard only in brilliant displays in which there is a lively motion. The actual heights of the visible auroral curtains or streamers which have been measured are generally greater than sixty miles, and of course any sound produced sixty miles away would not be heard. Further, the sound would require several minutes to travel such a distance, but various observers state that the sight of the special moving feature of the display is simultaneous with the hearing of the sound. As the "curtain" approaches, the sound increases in intensity, and as it moves away, the sound falls off. It is clear then that the immediate source of the sound which one hears need not be where the visible portion of the aurora is located; indeed it cannot ordinarily be there.

But one need not be where the lightning strikes to be affected by it. Even at a considerable distance one may be severely "shaken up" by the so-called return shock, which is due to electric induction.

Now the aurora is an electrical phenomenon, probably due to electrified particles projected from the sun. When these enter our atmosphere they excite the luminosity which we see. Their motion alters the earth's magnetic field and produces what is known as a magnetic storm. When the aurora shows rapid motion, there must be rapid changes in the electrification of the air, and these changes induce rapid changes in the electrification of the surrounding space, even at a considerable distance. Possibly these changes in the space about us give rise to something similar to a brush discharge from a body charged to a high potential. The sound which the aurora gives out is similar to that of a brush discharge.

STAR MYTHS

By C. R. COUTLEE

(Concluded from last issue)

Sagittarius, the archer, represents, according to the Greek myth, the centaur Chiron, son of Saturn who changed himself into a horse to outwit his wife. There is also a legend that Apollo urged the moon goddess Diana, (Artemis), to aim an arrow at the sun, thus killing Orion, his rival, who was hidden by the glare. Chiron educated Aesculapius and other Greek youths, especially in archery, he having brought a famous bow from Crete.

Capricornus, the sea goat, is considered with Cancer as the two most inconspicuous asterisms, but yet they have both been found upon boundary stones in Babylon. It is identified with the story of Pan and other deities feasting in the woods when the giant Typhon frightened them and Pan changed shape. Plunging into the water he became a fish below and a goat above. Jove was so amused that he recorded the event in the sky. The Cornucopia is ascribed to this group, as Jove gave a goat's horn to the nymph who nursed him as an infant and it poured out whatever she wished. It is said that it represents a fertile piece of land in Crete shaped like a horn which the king gave his daughter Amalthea, who, the poets say, nursed Jove. Peru celebrated a bread feast of plenty when the sun was in Capricornus, showing a common idea on opposite sides of the globe.

Aquarius, the water bearer, represents Ganymede, son of the King of Troy, taken up by Jupiter's eagle, while tending his flocks on Mount Ida, to replace Hebe as cup bearer to the gods. In Peru it was called the mother of waters and the Saxons called it the water god. The ancients considered this part of the heavens to be the sea of the sky and peopled it with the whale, fish, dolphin, sea goat, and even Pegasus was the emblem of navigation and belonged to Neptune.

Pisces, the fishes, represents Venus and her son Cupid, who were bathing in the Euphrates when Typhon, the giant, frightened

them and they both disappeared into the river, turning into fish tied together by a garland. Minerva commemorated the event by placing this group in the sky as Jupiter had done to record Pan's escape on the Nile. Typhon was finally placed under Mount Aetna. This was the national constellation of the Jews.

Auriga, the charioteer, has lost its origin in antiquity, but the Assyrians called it the chariot, and a figure holding a goat on the left arm appears among the sculptures of Babylon. It is identified with Erichthonius, the lame son of Vulcan, who invented the chariot. Capella is called the driver and was known as the Shepherd's star. When the kids glitter there is supposed to be bad weather coming.

Ursa Major, the great bear, is the best known constellation and the Greek myth imagines that, to escape the wrath of Juno, Calisto was turned into a bear by Jupiter and placed in the sky to avoid the arrows of Diana. Calisto's son, Arcas, became the Little Bear. Our Indians say that a party of hunters and the bear they pursued were taken up to the sky. When the bear is hit with an arrow his blood turns the leaves red. The Algonquins and Iroquois have a drama concerning the bear hunted through the spring, summer and autumn by robin, chickadee, owl, etc., and finally killed by the robin whose breast is stained.

Ursa Minor, the little bear, was called by the Greeks, Cynosura. They however used Helice (Ursa Major) for steering ships, but the more expert Phoenicians used the pole star. The Little Bear represents Arcas, son of Calisto. Both bears are supposed to have saved Jove from his cannibal father, Kronos, and nursed him on Mount Ida. The Indian legend states that some hunters were lost when a child from the gods appeared telling them that he was the pole star and led them home. When the hunters finally died they formed the other stars in the asterism. Polaris is the most useful star, it led the Assyrian armies, the Phoenician ships, the Roman Triremes, Columbus, the Spanish Armada, the escaping slaves from the south, and the Turks call it Yilduz, the star par excellence.

Boötes, the bear driver, comes from the Greek meaning "Shouting Driver". It is often confused with Erichthonius and Auriga. This constellation is very ancient and its lucida, Arcturus, is called Job's star. The Chinese called it the Palace of the Emperors and

the Arabs considered it as a dog guarding the pole which they called the sheep fold.

Canes Venatici was originated only in 1690. Cor Caroli was named in memory of Charles I, although Charles II founded Greenwich.

Orion, the huntsman, is supposed to have pursued the Pleiades which changed into doves while he was chased by the bull. He boasted himself conqueror of all animals when a crab, at Juno's command, bit his foot. Diana loved him but Apollo induced her to shoot into the sun, killing Orion who was hidden in its rays. Orion tried to elope with the daughter of Chios, but had his eyes put out. He then followed the sound of Vulcan's hammer to his forge whence a Cyclops carried him to a mountain top and the rising sun restored his sight.

The Great Dog, with the star Sirius in its mouth, represents the dog given to Cephalus by Aurora that could outrun a fox. In Egypt it is known as the Porter or Dog Headed God Anubis, which gave warning of the rise of the Nile.

The Little Dog is not a fierce hunter but a house-dog and represents the favourite of Helen, that she prayed Jove to place in the sky.

Eridanus, or river Po, represents the stream into which Phaeton was hurled from the chariot of the sun by the thunder bolt of Jupiter, when the horses became unmanageable. The sisters of Phaeton, the Heliades, mourned till the gods turned them into poplars along the river bank, their tears being drops of amber.

Hydra, the water snake, was the Lernean serpent killed by Hercules, who, helped by Iolaus, seared the heads with fire as he cut them off to prevent them growing again. The immortal head they buried under a stone and he poisoned his arrows in the blood.

Corvus, the crow, was originally white but became black from tale bearing. Apollo put it in the sky to watch the mother of Aesculapius. It is also said to be a crow sent for water that loitered by a fig tree till the fruit ripened. It brought back a snake in its claws, to explain the delay. It was doomed to thirst in the sky, the snake guarding the cup of water.

Crater, the cup, is supposed to have been given to Icarius by Bacchus, or it represents the cup of Medea, the sorceress, wife of Jason.

Argo Navis, the ship *Argo*, is supposed to have been built 80 years before the fall of Troy by Argo to carry the 50 heroes, Jason, Hercules, Glaucus, etc., who brought back the golden fleece from Colchis.

Corona Borealis, or the northern crown, was the one Bacchus gave Ariadine, daughter of Minos, King of Crete. She gave Theseus a sword with which to kill the minotaur and also a thread by which he escaped from the labyrinth, but alas her knight deserted her at Naxos.

Hercules, the one who kneels, was a son of Jupiter, whom Juno sent serpents to strangle. The infant killed them however, and was educated by Chiron, but had to serve Eurystheus for whom he did twelve tasks: killing the lion, the hydra, the stag and the boar, cleaning the stables, overcoming the birds, the bull and the wild mares, securing the belt of the Amazon queen, Geryon's oxen, the golden apples and bringing Pluto's dog up to earth. He also joined the Argonauts, helped the gods against the giants and pillaged Troy. For a time he was insane and tried to steal the tripod from Delphi but was made the slave of the Queen of Lydia for three years. His wife unwittingly gave him a cloak poisoned with the blood of the centaur Nissus, so he mounted his own funeral pyre and was wafted to heaven.

Draco, the dragon, was set to guard the stars which hung from the pole, or the golden apples in the garden of Hesperides, for the daughters of Atlas. It is also thought to be the snake snatched from the giants by Minerva and hurled uncoiled into the sky, or perhaps the one killed by Cadmus when searching for his sister, Europa. Likely the same idea survives in St. George and the Dragon.

Ophiuchus, the serpent bearer, was a great physician, perhaps Aesculapius himself, who is always associated with serpents, possibly because he could cure their poison. Aesculapius was the surgeon of the Argonautic expedition, another connection between the constellations and the ancient sea.

Cygnus, the swan, represents Orpheus, who, when he lost Eurydice in Pluto's world, drowned himself, his lyre floating down the river sounding her name till Zeus caught it up and placed it in the sky. Also one of the forms taken by Jupiter to kidnap Leda. It is also taken to be a relative of Phaeton, who, lamenting him, plunged into the Eridanus and was changed into a swan. It forms a more perfect cross than the southern cross, and stands vertical in the west at Christmas time, near the top is the northern coal sack.

Aquila, the eagle, was the bird of Jupiter, which brought him nourishment when hiding from his father Saturn in Crete. It also furnished him with thunder bolts against the giants and was sent to abduct Ganymede when he was made cup bearer in place of Hebe.

Delphinus, the dolphin, was reputed by the Greek poets to have persuaded Amphitrite to abdure celibacy and wed Neptune, for which it was placed in the sky. Also when the poet Arion was about to be murdered by a pirate crew, he begged to play the lute which attracted the dolphins, one of which took him home to Lesbos on his back. They were the messengers of Neptune and emblems of philanthropy, and said to herald the opening of navigation.

Lyra, the harp, represents the celestial lyre which Mercury gave Apollo, who in turn gave it to Orpheus, musician of the Argonauts. With it he charmed Pluto and got back his lost bride, Eurydice, who unfortunately, like Lot's wife, looked back and was lost. This refers to the morning dew issuing from the black night only to be lost in the sun.

Pegasus, the flying horse, that sprang from the blood of Medusa when Perseus cut off her head. Mount Helicon was his home and striking the rock with his hoof, the spring Hippocrene burst forth making the poet's river of inspiration. He was a great favourite among the gods, and was lent to Bellerophone to aid in conquering the Chimaera. The brother of Pegasus was given to Castor by Mercury, or to Pollux by Juno.

Cepheus, the King of Ethiopia, is identified with Cheops, builder of the great pyramid, and was one of the Argonauts. This

again points to depicting imperishably in the sky the story of the Argonautic expedition.

Cassiopea, the wife of Cepheus and mother of Andromeda, boasted that her daughter was fairer than the sea nymphs. They complained bitterly to Neptune, who sent a sea monster to ravage the coasts.

Andromeda represents the princess royal, whom Jupiter had chained to the rocky shore to be devoured by a sea monster in expiation of her mother's boastfulness. In Hebrew and Phoenician the name meant a long rocky shore, so Andromeda, or some coast town belonging to Cepha, the rock, suffered perhaps through famine and was delivered by Perseus, which means a runner or ship. Josephus states that the rock and chains and bones of the sea monster were shown to travellers in his day.

Cetus, the whale, is considered to be the sea monster in the Andromeda legend. The ancients thought that all the monsters inhabited the sea, perhaps referring to a region below the horizon, or to some great flood. St. Jerome states that the bones of this monster were brought from Tyre to Rome.

Perseus, the champion, was a son of Jupiter and favourite of the gods. He and his mother were placed in a chest and cast into the sea, but floated to an island and were made slaves of the King Polydectes, who sent Perseus to kill the Medusa that ravaged his kingdom. This was done with the aid of Mercury's wings, and Minerva's shield used as a looking glass. Returning with Medusa's head, he heard the sobs of Andromeda; so, like a knight-errant, he attacked and killed the monster Cetus, released Andromeda from her chains and married her.

The Galaxy, or milky way, was reputed to be the stream into which Phaeton was hurled. It was also the path of the sun at the beginning of the world, and the way of souls to heaven. The gods lived along either side of this star stream in golden habitations.

These legends and fables are all still worth while. For many centuries millions of our forefathers learned of these gods in their homes. They lived in faith, and died with prayers to them upon their lips at Thermopylae and for Rome.

Ottawa, Ont.

THE UPPER ATMOSPHERE

By JOHN SATTERLY

INTRODUCTION

IN the Proceedings of the Royal Society of London on January 1st, 1923, there appeared an intensely interesting paper by Professor F. A. Lindemann, F.R.S., Professor of Experimental Philosophy in the University of Oxford, and Mr. G. M. B. Dobson, M.A., Lecturer in Meteorology in the same University. Its title is "A Theory of Meteors and the Density and Temperature of the Outer Atmosphere to which it leads". The fact that two of its conclusions are in opposition to the generally accepted views about the upper atmosphere has caused a great deal of comment and discussion.

Before taking up the new views it might be just as well to recall the current theories about the atmosphere. These views are well given in Jeans' "Dynamical Theory of Gases" (Cambridge University Press, 1921) and Humphreys' "Physics of the Air" (Franklin Institute, 1920).

On the matter under consideration Humphreys says: "(1) The temperature (of the atmosphere) decreases uniformly at the approximate rate of 6° C. per kilometre (10° C. per mile) from 11° C. at sea level to −55° C. at an elevation of 11 kilometres. The region up to the 11 km. level is termed the 'troposphere'. (2) Beyond 11 kilometres the temperature remains constant at −55° C. This region is called the 'stratosphere' and its isothermal nature was discovered by Teisserenc de Bort about thirty years ago. (3) Up to the level of 11 kilometres the relative percentages of the several gases, excepting water vapour, remain constant—a result, of course, of vertical convection. (4) Above 11 kilometres, where the temperature changes but little with elevation, and where vertical convection therefore is absent, the several gases are distributed according to their several molecular weights."

He gives a table and a diagram which has been often reproduced showing how the relative amounts of the gases in the atmosphere

change as the elevation increases from 11 kilometres up to 140 kilometres. The most noticeable feature of the diagram is the increasing preponderance of nitrogen over all the other gases up to 50 kilometres, followed from there onwards by an increase of the relative amount of hydrogen until at 150 kilometres the atmosphere is practically *all hydrogen*, the pressure at this height being only four millionths of the pressure down at the surface of the earth.

Humphreys adds that the figures given in his tables and diagrams and the constancy of the −55° C. in (2) above are supported by direct experimental evidence obtained with "sounding balloons", which have been sent up to a height of about 30 kilometres only. Although the theory seems sound, deductions from it become more and more insecure as we get into parts of the atmosphere much higher than this.

There is, however, great doubt about the presence of hydrogen in the atmosphere. Chapman and Milne (Royal Meteorological Society, 1920) suggests there is "none". If they are correct then the preponderating gas in the atmosphere at very high levels would be the next lighter gas, namely, helium. Jeans has also shown that if the temperature of the outer atmosphere is above 277° C. we should lose our hydrogen.

Occasionally a balloon has recorded a temperature increase in the stratosphere. In 1905 a reading at Strasbourg in France indicated that at 26 kilometres the temperature was 20° higher than at 14 kilometres.

To come to Lindemann and Dobson's paper. It would be impossible here even to summarize all the mathematical deductions. All that we can do is to abstract the paper and emphasize the important points. This article is therefore more of a digest than an essay. After pointing out that our direct knowledge of atmospheric conditions only tells us what is happening up as far as 25 kilometres, a study of meteors has convinced them that the density of the atmosphere above 65 kilometres is much greater than is usually supposed, in fact, a thousand times greater (see p. 10) and that the temperature which is about 220° absolute (−50° C.) at heights between 12 and 50 km. rises to something like 300° absolute (=27° C.=80° F.)—a hot summer's day temperature—at 50 km. These "facts" have been deduced from the heights of

appearance and disappearance of the meteors, their length of path, velocity and luminosity.

Most of the meteoric data was collected by W. F. Denning of Bristol and his co-workers, who have been indefatigable for many years in working out the details of meteoric streams. By meteors are meant the shooting stars and not the larger meteorites and fireballs. Thus the great meteorite of February 9, 1913, so well described in Dr. Chant's paper (ROY. AST. SOC. OF CANADA JOURNAL, May-June, 1913, and later numbers) does not come within the scope of Lindemann and Dobson's mathematics.

PART I—METEORS

The results of Denning's observations on some thousands of meteors give us these general results. Meteors appear at heights between 160 and 90 kilometres (8 kilometres = 5 miles), and usually disappear at heights below 120 kilometres (mostly at 80 kilometres). The estimated velocities range from 10 to 160 kms. per second and have all directions from horizontal to vertical. The brightness varies enormously; from that of a full moon down to that of a seventh magnitude star.

In their mathematical work Lindemann and Dobson assume as a typical meteor one that appears at a height of 10^7 cms. (= 100 kilometres = 60 miles), disappears at 8×10^6 cms. after travelling a distance of 6×10^6 cms. at a velocity of 4×10^6 cms. per second and appearing for about $1\frac{1}{2}$ seconds as bright as a first magnitude star, the output of energy of such a star during its luminous period being at the rate of 4400 H.P.

Lindemann and Dobson accept the usual explanation of meteors, namely, that "a meteor appears when a cosmic particle of matter moving at a sufficiently high speed relative to the earth, becomes heated by atmospheric friction to such a temperature that it evaporates, and that it disappears when all the matter originally present has evaporated. The molecules which distil off the meteor, as also the molecules of air in its path after collision, are moving at approximately the speed of the meteor and lose their kinetic energy largely in the form of radiation, by collision with other atmospheric molecules."

Head Resistance of Particle.—An important fundamental mathematical deduction in their work is that of the head resistance of the particle. The meteor moves much faster than a sound wave, and therefore much faster than the air molecules, and in its sweep through the atmosphere it piles up in front of it a cushion of air which by the adiabatic compression is raised to an extremely high temperature. Abstracting their mathematics and putting the matter as simply as we can we may say that if

S = the cross section of the meteor,

v = its velocity,

ρ_0 = the density of the air,

the amount of air accelerated in a short time $\delta t = S\rho_0 v\,\delta t$.

If m' = mass of air accelerated by the meteor we may put $m' = S\rho_0 v$ and the kinetic energy given up per second to accelerating this air $= \frac{1}{2}(S\rho_0 v)v^2$.

This is the major part of the energy abstracted from the meteor per second; the energy devoted to mere compression of the gas being negligible.

If p = pressure in this head of gas, the force on the meteor $= pS$. Therefore the work done by meteor per second $= pSv$ and this $= \frac{1}{2}(S\rho_0 v)v^2$ whence $p = \frac{1}{2}\rho_0 v^2$ and the head resistance $= pS = \frac{1}{2}S\rho_0 v^2$.

Temperature of Surface of Particle.—What will be the temperature of this compressed gas? Since the compression is adiabatic, the relationship between temperature and pressure is

$$T_1/T_0 = (p/p_0)^{(\gamma-1)/\gamma}\ *$$

Now $p = \frac{1}{2}\rho_0 v^2$

and therefore $p/p_0 = \frac{1}{2}v^2(\rho_0/p_0) = \frac{1}{2}v^2(RT_0/M) = Mv^2/2RT_0$, where M = molecular weight of the gas and R is the universal gas constant $= 8.4\times10^7$ erg/degree. In the case of nitrogen $M = 28$, and if $v = 4\times10^6$ cm/sec. and $T_0 = 220°\ K$ (the temperature of the isothermal layer), T_1 will exceed $3200°\ K$.

(*Note:* The boiling point of iron at atmospheric pressure is $2720°\ K$; "degrees K" mean degrees on the Absolute Scale, centigrade in this case.)

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*See an elementary textbook of heat, *e.g.*, Stewart and Satterly, Heat, p. 439. γ is the ratio of the specific heat at constant pressure to the specific heat at constant volume and for air = 1.40.

Some of the heat generated flows from the gas into the meteor. At low pressures the molecules would impinge directly upon the meteor but at higher pressures they impinge upon the cap of compressed air and vapour built up in front of the meteor. The former does not appreciably heat the meteor; the heat supplied to the meteor by the latter can be calculated from the kinetic theory of gases. It is a fraction of the work done by the meteor, the value of the fraction depending on the temperature.

Explanation of Meteors.—"The only tenable explanation is that the meteor becomes visible when its surface becomes hot enough to evaporate appreciably, and its fast vapour molecules collide with the air molecules. It disappears when it has evaporated practically completely. The velocity changes little in this process, also the radiation that comes to us and by which we see the meteor has its source in the vapour; the radiation from the particle is negligible."

A possible modification is that of a particle and the rush of wind past the molten surface produces a luminous spray. This spray of luminous matter would spread out like a fan and the cross section of the luminous trail which follows the meteorite would be much larger than in the case of the upper meteors. This could only occur at the lower levels of the atmosphere and produces the large meteors or meteorites. These are of the type of which the meteorite of February, 1913, is a splendid example (*vide* Dr. Chant's paper).

Mass of Meteors.—Most of the kinetic energy of the particle is transformed into radiation. A little goes into heating and volatilising the meteor, the great majority, however, goes into collision and ionisation which produces visible radiation. We may therefore equate the energy to the radiation output. Taking the case of a typical meteor travelling a luminous path of 6×10^6 cms. in 1.5 seconds and appearing at a distance of 1.5×10^7 cms. as bright as a first magnitude star, the energy output is (see p. 4) equal to 5×10^{10} ergs, and from the equation

$$\tfrac{1}{2}mv^2 = \text{energy}$$

we get

$$\tfrac{1}{2}m(6\times10^6 \text{ cm}/1.5 \text{ sec.})^2 = 5\times10^{10},$$

whence $m = 6\times10^{-3}$ gram.

This is a remarkable result. Not many of us would have had any idea that the mass of the shooting star which makes such a bright streak in the sky is about as much as that of a drop of water whose diameter is one-twelfth of an inch. If the meteor were made of iron the diameter would be only one twenty-fourth of an inch. Much brighter meteors must be either faster or greater. If a meteor which moved at the same speed and lasted the same time as the one above appeared as bright as the full moon its mass would be 62 gms. (=2 ounces) and its diameter 2.5 cms. (=1 inch).

Oxidation and Evaporation of Particles.—There is little oxidation of the solid meteor at such heights; the escaping vapour will presumably be oxidised finally but this will alter only slightly the total energy emitted. (With slow meteorites at low altitudes oxidation is an appreciable aid to the radiation.)

Taking the equation

$$T_1 = T_0(Mv^2/2RT_0)^{(\gamma-1)/\gamma}$$

proved above, it is seen that taking velocities (v) of 20, 40, 60, 80 km/sec. and T_0 as 300° K, the values of T_1 are 2700°, 4000°, 5100°, and 6000° K, respectively. This shows the relation between meteoric speed and temperature.

Height of Appearance of Meteors.—Meteors appear suddenly, *i.e.*, they do not shine faintly at first and then get brighter. The reason is this: In the first stage the meteors collide so violently with the molecules of the air that it meets that these molecules are broken up and nearly all the energy is lost by radiation. It is only when evaporation is considerable and the cloud of vapour is slowed up by the air that the meteor becomes bright. Evaporation can only become considerable when some of the heat passes within the surface of the particle. If the meteor is small, little time will be required for this. (For greater speeds and higher densities this would not be so, *e.g.*, meteorites.) By making an equation between the rate of heat flow to the surface and away into the interior, Lindemann and Dobson are able to work out with fair accuracy the density of the air at the place of appearance of the meteor. By taking into account the rate of evaporation (making the assumption that the meteors are of iron or some stony material, like olivine) they were also enabled to deduce values for the density of the air at the heights of disappearance of the meteors.

Part II—Application to Meteorology

The main object of the paper so far has been to deduce the atmosphere density at great heights. Several hundred of Mr. Denning's observations have been used. As a rule the observed

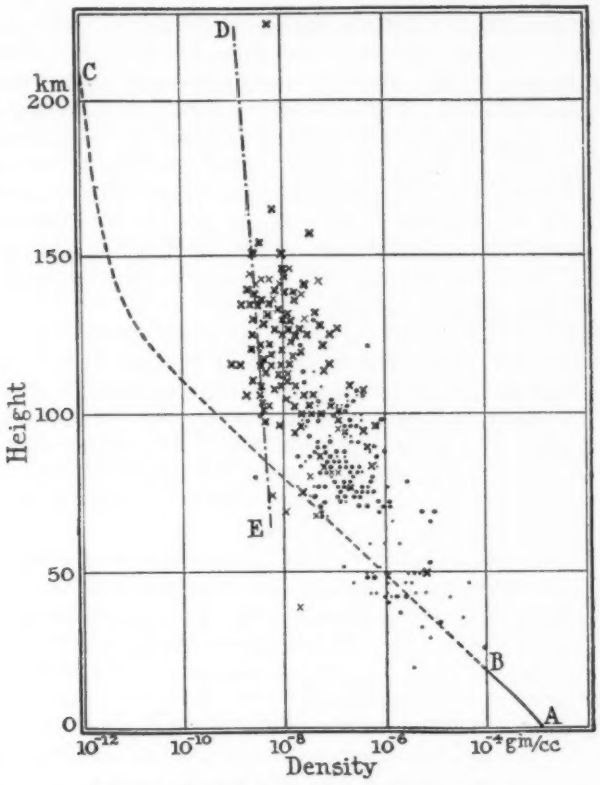

Diagram showing the density of the atmosphere at different heights

heights and length of path are fairly accurate; not so much can be said for the estimated speeds and brightness.

Height of Appearance of Meteor.—Having the density at different heights, the change of density with height enables the true temperature to be calculated. The molecular weight of the gases of the atmosphere is required and up to 130 km. there are reasons for thinking the gases are predominantly nitrogen and oxygen. "The observations are definitely against the hydrogen atmosphere with which we have become so familiar in the works on meteorology and mathematical physics." Lindemann and Dobson draw a chart between height of level in atmosphere and density which is reproduced herewith. The only part that we know anything about by direct experiment is AB, which is obtained by "ballon sonde" experiments and gives us the density up to 20 kilometres (12 miles). The dotted curve BC is drawn on the assumption that the conditions above the troposphere are isothermal at 220° K. The points marked "x" represent heights calculated from appearances of meteors and points marked "." represent heights deduced from the disappearances of meteors.

It will be noticed that the points calculated from meteoric data agree with the extension of the line from "ballon sonde" experiments from 20 to 50 km. From 60 to 160 km. meteoric data give densities greatly in excess of those indicated by BC and the calculations on the rate of change of density with height support a temperature in those regions of 300° K rather than that of the previously accepted value 220° K. Their results are entirely opposite to previously accepted views.

The new density at 150 km. is of the order of 1000 times the old density, and though the meteoric data give points which are quite a bit scattered over the chart, not one occurs anywhere near the region which would contain points marking a density which would correspond to an atmospheric temperature of 220° K instead of 300° K.

Supporting Arguments.—Luckily there are three other arguments, all independent, which lead to the same result, namely, a high temperature above 60 km. The first one is from the density of the cap of compressed gas which forms in front of the meteor. This cap has to be formed before any heating can occur, and naturally since it comes first in time it has to form at heights greater than that at which the meteor appears. The densities

calculated from the formation of the cap give us the line *DE* in the diagram. It will be seen that it fits in well with the other observations being, as it should be, to the left of the great multitude of points calculated from observations of the appearance and disappearance of meteors.

No Meteors at 55 km. high.—It will be noticed that few meteors appear at heights between 50 and 60 km. If the very upper atmosphere is at 300° *K* and the stratosphere from 50 to 60 km. is down to 220° *K*, a meteor on entering this cold region would not warm up as fast as it did before and the production of luminosity would be retarded until the meteor entered a warmer and denser region. Again, if we restrict ourselves to meteors which occur in parts of the atmosphere where oxidation is not likely to be a large source of heat, the meteor's surface must be heated to a certain high temperature before it gives off enough vapour to become visible. Therefore there will be a minimum velocity below which no meteor should appear. This minimum velocity depends on the air temperature being 12 km/sec. at 300° *K* and 19 km/sec. at 220° *K*. There are many observations of meteors having speeds less than 19 km/sec., thus supporting the 300° *K* argument.

Aurora.—It is important to know the density at levels of 100 km. because the value of this density enters into the theories put forward to explain aurorae. Aurorae come down to the 100 km. level and the new value of the density at this level is 100 times the old value.

The width of a spectrum line varies as the density of the gas varies, and observations on the widths of the nitrogen lines in the auroral spectra are now wanted to see how they agree with a density of 10^{-8} gm/c.c. instead of with the previously accepted 10^{-10} gm/c.c.

A re-examination of the *assumptions* made shows that if Lindemann and Dobson's assumptions are not justified any attempts to make them more reasonable leads only in the direction of higher densities than those calculated, and thus Lindemann and Dobson conclude that the temperature at great heights is of the order of 280° to 300° *K*.

Possible Explanation of the Calculated High Temperature.—It now remains to give some plausible explanation of this high

temperature, and Lindemann and Dobson put one forward based on the radiative equilibrium of a mass of gas which is heated by radiation from the sun and the earth and which loses energy by radiation corresponding to its own spectrum lines. They build up an equation which is applied to different gases in turn. Thus carbon dioxide would take up a temperature between 206 and 236° *K*, water vapour between 200 and 237° *K*, and nitrogen, oxygen, helium, hydrogen would acquire the temperature of the earth (280° *K*). A favourable picture is presented by ozone. This, if present, would take up a higher temperature, and it is quite likely that at heights above 60 km. the ultra-violet radiation from the sun would produce ozone from the oxygen and its influence would preponderate over the other gases on account of its greater absorptive power. In the lower levels where CO_2 and H_2O are present their effect would preponderate and this might account for the lower temperature of the troposphere.

Supporting Evidence from Other Sources of Information.—"Nature" of January 20 contains a letter from Mr. R. M. Deeley, stating that he suggested in 1918 that the stratosphere over the poles is warmer than that over the belts 30 N. and S. of the equator. The information was derived from the records of self-recording balloons and extrapolating to greater height.

"Nature" of February 10 contains a letter from Mr. F. J. W. Whipple to the effect that the presence of a silent zone around an explosion area and an audibility zone outside this may be explained easily if the atmosphere at heights such as 80 km. is hot. "Sound waves penetrating that region would be refracted back to earth, the comparatively rapid curvature of the sound rays making the phenomenon almost equivalent to reflection as is the case with the light rays which occasion the 'mirage'." Assuming a sharp transition from 220° *K* to 280° *K* this gives a refractive index from one layer to the other of 1.13 and if the critical reflection occurs at a height of 60 km. the minimum radius for the outer zone of audibility is 155 km. As a matter of fact for the big Dutch explosion of October, 1922, the distance was about 190 km.

I have attempted in the above pages to give readers an outline of Messrs. Lindemann and Dobson's theory. I am afraid the result is rather uneven and not very convincing. This is because

the paper itself is so concentrated that nearly every paragraph it contains is necessary for the argument. I hope, however, that I have given enough to convince readers of the interesting nature of the original paper and perhaps enough to persuade them to turn to the paper itself. At all events I hope they will now be able to follow the reports of the discussions on this paper which are appearing in nearly all the journals which cater for meteorology, astronomical physics, and general science.

University of Toronto,
May, 1923.

REVIEW OF PUBLICATIONS

The Distribution of Energy in the Spectra of the Sun and Stars, by C. G. Abbot, F. E. Fowle and L. B. Aldrich.

In this paper, which is Vol. 74, No. 7, of the Smithsonian Miscellaneous Collections, the methods employed in previous determinations of the solar energy curve are briefly outlined together with the more recent determinations. The following factors are involved in these determinations:

(*a*) The intensity of the spectrum observed in the bolometer.
(*b*) The selective transmission of the spectroscope.
(*c*) The selective reflection of the coelostat.
(*d*) The transmission of the atmosphere.

The writers have at no time taken account of selective absorption. Though the possibilities of error from this cause have not been eliminated experiments with various types of bolometer show no difference beyond the experimental error and the estimated absorption coefficient of blackened surfaces for total solar radiation is at least ninety-seven per cent. Hence it is considered a safe assumption that the bolometer absorbs a uniform proportion of the rays throughout the spectrum from 0.3μ to 3μ.

The 1922 determinations, made at Mt. Wilson, were the outcome of a very marked discrepancy shown by the determinations of 1920. The apparatus used was entirely new as the 1920 outfit had been sent to Mt. Harqua Hala. As it was felt that the principal uncertainty rested on the determination of the absorption of the spectroscope the ultra-violet crown glass prisms were replaced by rock salt prisms to give instruments of different dispersion characteristics. In the auxiliary spectroscope an ordinary flint glass prism replaced the ultra-violet glass prism, the former giving a far greater relative dispersion in the ultra-violet.

So many closely agreeing determinations of the transmission of the atmosphere have been made in past years that it was felt these coefficients were sufficiently accurate for the purpose in view, at least for wave lengths greater than 0.4μ. If, after using

various types of bolometers, under various conditions, and different prisms, the results should agree with those of other years it was felt the final results ought to be entitled to confidence.

In the ultra-violet region there is an error introduced by the effect of stray light from longer wave lengths. This stray light makes the atmospheric transmission coefficients for the ultra-violet region too high, resulting in a diminution of the intensities of the solar energy spectrum outside the atmosphere for that region. It also builds up the bolographic energy curve at the Earth's surface in the ultra-violet, and, by rendering the auxiliary spectrum too bright, indicates a greater absorption in the spectroscope than actually exists, thus tending to make the ultra-violet part of the solar spectrum outside the atmosphere too high.

The solar energy curves are given for 1922, both with ultra-violet glass prisms and rock salt prisms. Curves are also given representing the results of 1920, the mean of 1920 and 1922, the mean of 1903 to 1910, and the distribution of energy in the spectrum of the perfect radiator at 6000° absolute centigrade. Considering all circumstances the rock salt work of 1922 is in remarkable agreement with the work of 1920 and the ultra-violet glass work of 1922 agrees almost perfectly with that of 1920 between wave lengths 0.5 and 1.7 microns. Below 0.5 there is a rather wide divergence attributed to inferior sky conditions in 1922. Owing to weather conditions the work of 1920 and the rock salt work of 1922 were weighted double below wave length 0.5 microns and the three results weighted equally above this point to give the mean for 1920 and 1922, the resulting mean curve being considered the best determination of the solar energy curve outside the atmosphere. A comparison with the mean of 1903 to 1910 reveals the fact that the quartz prism has caused most of the disagreement, elimination of the results from this prism giving very good agreement with the new determination.

Two reasons are given for the divergence of the mean curve of 1920 and 1922 from the black body energy curve. First, the longer the wave length the less the rays are scattered, hence the deeper we see into the Sun and so the infra-red part of the spectrum is supplied from a deeper and so hotter layer. Secondly, the profusion of Fraunhofer lines in the visible and ultra-violet cut down

this part greatly. Stray light also has an effect here, tending to make the real curve deviate still further below the black body curve in the ultra-violet.

An interesting point is noted in plotting Fabry and Buisson's ozone values as abscissae with solar constant values as ordinates, the resultant curve indicating that increasing values of the solar constant are associated with decreasing values of atmospheric ozone. This would mean that the absorbing properties of the infra-red ozone band at about 10.4 microns would vary with changes in solar radiation in such a way as to diminish terrestrial temperatures as solar radiation increases.

The latter part of the paper gives an account of similar work on stellar spectra carried out also with the 100-inch. The positions of maximum ordinates in the observed stars, which embrace most of the spectral types, shift with spectrum type as expected, with fairly good agreement between Capella and the Sun. No definite conclusions can be reached however with the low degree of accuracy claimed. The resultant curves are only the outcome of preliminary experiments and as such they are published, the work being justified by the fact that it shows what equipment is required and it opens the way to further experiments of a very much higher degree of accuracy.

R. M. MOTHERWELL.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

Something Yet to Learn

While gathering the evidence regarding the audibility of the aurora which is printed in this number of the JOURNAL, I had a conversation over the telephone with an elderly lady living in Toronto who has been an invalid for many years. The experiences described by her were certainly remarkable, and at my request she wrote out the brief statement which follows.

In the late sixties, in midsummer, in my father's home, the old Lundy homestead of my great-grandfather, I encountered a number of lights moving around among the tree trunks, plainly auroral, having the same effect on me. I am naturally possessed of too much "electricity", or "magnetic force", or some other kind of "force"—my watch would never keep time!—and these moving lights made me dizzy and nauseated. They were vertical and made one think of long robed arms. On reporting indoors I was laughed at, but some members of the family (I do not remember who) went out and saw them. I heard no noise.

Later, about twenty years ago, being again at my old home, I was awakened by the distress in my spine which, I have learned to know, means that the morning papers will tell of some disturbance of the telegraph and telephone lines. I went out to investigate, and was rewarded by one of the most wonderful of the many memorable experiences of a long life. In the north-eastern sky was a small but magnificent aurora, in form resembling the photographs of a sun-spot, but vividly coloured, reds predominating. Accompanying, was music which made one recall the poetic Old Testament imagery, "When the morning stars sang together and the sons of God shouted for joy". It was unmistakable music, and was like the music produced by violin strings when the violin is on or near a piano.

Now what does all this mean? A person who has had a training in experimental science is disposed to dismiss such statements as due to a lively imagination or to disordered nerves. I must confess that I am at once inclined to suspect that the person who has had the extraordinary experiences has been deceived; and yet there is always a doubt whether one is justified in disposing of the matter in such a simple dogmatic way. We sometimes meet intelligent people who are certainly honest in their beliefs and would not knowingly deceive, who seem to have peculiar sensibilities which ordinary people cannot appreciate or understand.

What were those "lights moving around among the tree trunks?" From the description given one would hardly think they were auroral, and yet they seemed to produce the same effect on the person observing them. They might possibly be explained on ordinary physical principles if we had sufficient information to guide us. But what was their relation to the dizziness and nausea?

Again, in the later experience why was the person awakened by her bodily distress? Was it due to variations in the earth's magnetic field accompanying an auroral display? A physician friend expresses to me a strong suspicion that some persons are affected by the earth's magnetism, and that it is a matter of some importance whether they sleep in a north-south or an east-west direction. The apparition in the north-eastern sky may not have been auroral and the accompanying music could be explained as an aeolian harp effect. But after allowing for imperfect description and possible deception in some parts, is there not something remaining which can hardly be simply brushed aside? We have still much to learn—indeed, there is more in Heaven and in Earth than is dreamt of in our philosophy.

A Very Special Kind of Furniture

A well known astronomer from the west visited his friends in the east recently, and while in the Book Department of one of the large departmental stores in Toronto asked if there were in the store any logarithmic tables. The saleswoman hesitated a moment and then replied: "I think you will find what you want in the House Furnishings Building".

A Brilliant Fireball

A brilliant meteor was seen at about 8 p.m. on September 1, in a direction about 5° W. of S. from Go-Home Bay (Long. 79° 57′ W., Lat. 45° N.). It fell almost vertically, moving a little to the east as it descended, and left a very bright trail behind it, which, however, did not long persist. It was bright enough to cause persons who had their backs to it to turn about and see the wonderful spectacle. From its brightness it was judged to be from 30 to 60 miles away, that is in the neighbourhood of Colling-

wood, Ont.; and it was hoped that there would appear in the newspapers some account of a meteorite having been found, but nothing has been reported.

The Moon and the Weather Again

The weather was warm and the sky appeared somewhat unsettled, and on meeting an Ontario Forest Ranger in the Muskoka region it was natural to ask him what he thought of the prospects of rain. He assured me that our fine weather would continue and that there would be no change until the moon would become new, which was to occur four days later (September 10—the day of the Mexican Eclipse). He was a big sturdy son of France, had sailed the ocean and had settled in Canada some years ago, being usually employed in out-of-door work. I said: "Do you really believe that the moon has anything to do with the weather?" "I certainly do", he replied in a decided manner, "I did not have seventeen years of salt water without finding that out. The moon controls both the tides and the weather!"

On the next day there were heavy winds, changing to all points of the compass and accompanied by heavy showers of rain, and a very unsettled state of affairs lasted for three days. Then the weather cleared and Monday, the day of the new moon, was bright and clear and perfect, and the partial eclipse was well seen. On Tuesday the sky was overcast again and considerable rain fell.

Though his prediction was far from accurate, I have no doubt that our obliging and amiable friend Pierre is still assured that the moon controls the weather.

C. A. C.

THE COPERNICAN SYSTEM

(From a bulletin published by the New Zealand Astronomical Society)

The Sun, revolving on its axis, turns,
And with creative fire intensely burns;
Impell'd the forcive air, our Earth supreme,
Rolls with the planets round the solar gleam.

First Mercury completes his transient year,
Glowing, refulgent, with reflected glare;
Bright Venus occupies a wider way,
The early harbinger of night and day;
More distant still, our globe terraqueous turns,
Nor chills intense, nor fiercely heated burns;
Around her rolls the lunar orb of light,
Trailing her silver glories through the night.

On the Earth's orbit see the various signs,
Mark where the Sun, our year completing, shines;
First, the bright Ram his languid ray improves;
Next, glaring watery, through the Bull he moves;
The amorous Twins admit his genial ray;
Now burning, through the Crab he takes his way;
The Lion, flaming, bears the solar power;
The Virgin faints beneath the sultry shower.

Now the just Balance weighs his equal force;
The slimy Serpent swelters in his course;
The fabled Archer clouds his languid face;
The Goat, with tempests, urges on his race;
Now in the Water his faint beams appear,
And the cold Fishes end the circling year.
Beyond our globe the sanguine Mars displays
A strong reflection of primeval rays.

Next belted Jupiter far distance gleams,
Scarcely enlighten'd with the solar beams;
With four unfix'd receptacles of light,
He towers majestic through the spacious height;
But farther yet the tardy Saturn lags;
And five attendant luminaries drags;
Investing with a double ring his pace,
He circles through immensity of space.

* * * *

These are Thy wondrous works, First Source of Good!
Now more admired in being understood.

THOMAS CHATTERTON (1752-1770).

[The planets Uranus and Neptune were not discovered until 1781 and 1846 respectively, and the first of the minor planets was not discovered until 1801.]

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